

## AUTOMATIC DETECTOR OF MEDIA INTERFACE PROTOCOL TYPE

This invention relates to packet-based communication systems and particularly to network switches, routers and the like which include a SERDES (serialiser/deserialiser) between a media access control device (MAC) and the transmission medium by means of which signals including the packets are conveyed to and from the media access control device. The invention particularly relates to systems conforming to IEEE Standard 802.3.

### Background to the Invention

Network switches, including for present purposes devices variously known as bridges, routers and brouters, may be connected to a variety of transmission media, such as copper cable or optical fibre, using either a 'physical layer entity', normally denoted PHY, or a SERDES. These devices are usually external to the switching ASIC performing the basic functions of the network switch. They employ a variety of interface protocols dependent upon the type of the cable and the 'port speed', that is to say the design data rate at which data may be sent from or received by the port associated with the particular MAC. The most common type of interface protocols used at present are the IEEE TBI (10-bit interface) protocol used to connect to fibre cables rated for gigabit data rates, and IEEE GMII 10-bit protocol which is used to connect the MAC to copper cable for gigabit Ethernet and the IEEE MII 5-bit protocol to connect the MAC to copper cable for '10/100 Ethernet', that is to say Ethernet type data at either 10 or 100 megabits per second. Recently other interfaces have been developed, such as the reduced gigabit media independent interface (RMGII) which supports a reduced 5-bit interface for PHYs supporting 1000/100/10 megabit per second Ethernet speeds on copper cable. At the same time a 5-bit reduced SERDES interface protocol has been agreed, termed RTBI.

SERDES devices for connection to fibre optic cable are different from PHYs used for connection to copper cable in that (assuming an 8-bit/10-bit encoding scheme) all the ten input and output pins of the SERDES carry data rather than the provision of some data bits and some control bits as in the GMII interface. The receiver side of the local switch's media access control device must be synchronised to the 10 bits of data from the

transmitter block of the SERDES associated with the switch at the far end of the link. Likewise the local switch's media access control transmitter block transmits 8-bit/10-bit encoded data to which the receiver of the SERDES at the far end of the link must be synchronised. As will be explained in more detail later, there are a multiplicity of code groups. One character or symbol of importance to the present invention is an idle (I2) symbol which is made up of two code groups. Several variations of the symbol exist. The receive sides of both the media access control device and the SERDES must decode and lock on to the idle symbols for communication to occur over a communication link.

As well as the recently defined RGMII and RTBI protocols, various manufacturers have produced variants of SERDES devices to support both the TBI and RTBI protocols. Various devices include interfaces relying on 10 bits or 5 bits using a single clock or two clocks on the receiver interface.

It is generally desirable to be able to support a variety of interface protocols and to enable products to be modular in form enabling any configuration of the interfaces to be plugged into the ports of a network switch. It is accordingly desirable to provide a means of identifying the SERDES device on the plug-in module in order that the software drivers for the media access control device can be correctly configured.

It is known practice to identify a plug-in card by using either a memory-mapped register or a plug-in module which is readable by an on-board processor (CPU) by means of a series of encoded pins, pulled 'high' or 'low' according to the device attached. However, both these methods involve using pins on a module connector and impose a space or cost penalty. A fully modular switch wherein all ports are of the plug-in type allowing support for testing a variety of different media types would add a substantial cost overhead to products.

### **Summary of the Invention**

5 The present invention is directed to the automatic detection of an interface connected to a port without the need for CPU interrogation by way of an interface or via pull-up/pull-down pins. In particular this will save on the pin count required at a plug-in port connector.

10 In particular, the present invention concerns a detector composed of clocked delays and gates and controlled by complementary clock signals at the appropriate rate to determine the interface protocol to which a two-group idle symbol conforms. A practical form of the invention employs the clocked delays to present for each interface protocol sufficient bits from the two groups simultaneously to comparators whereby to determine the existence of the code groups in accordance with the various protocols. The detector is organised to provide at any time at most a single valid output identifying the interface protocol actually employed. Preferably the detector distinguishes between 10-bit and 5-bit protocols which may employ either a single clock or two complementary clocks.

15 Further features of the invention will become apparent from the following detailed description with reference to the accompanying drawings, which illustrate both the background to the invention and a preferred implementation of the invention by way of example.

### **Brief Description of the Drawings**

25 Figure 1 is an explanatory diagram illustrating the connection of media access control devices to a variety of transmission media.

Figure 2 is a table illustrating various special code groups in 8-bit/10-bit encoding.

30 Figures 3 to 6 each illustrate a particular type of clock signal characteristic of different types of serialiser/deserialisers.

Figure 7 is a schematic diagram illustrating the disposition of a detector according to the invention in relation to a switch as shown in Figure 1

Figure 8 is a detailed schematic diagram of a detector according to the invention

### Detailed Description

Figure 1 of the drawings illustrates for the purpose of explanation possible different connections of the media access control devices within a switching ASIC of a network switch to such devices as a SERDES or physical layer devices (PHYs). The example given is of a network switch which is implemented (as is known practice) mainly by a switching ASIC 1 that includes a multiplicity of media access control devices (MACs) 2, 3 and 4, there being normally one of these devices for each port of the switch. The (conventional) packet switching and storage functions, the details of which are not relevant to the present invention, are denoted by the schematic block 5. It is presumed in this example that the MACs may be connected to a SERDES or PHY by an appropriate connector 6 and that each of these connectors 6 may be connected to, for example, a SERDES (serialiser/deserialiser) which has a port for connection to a fibre optic cable 8, a PHY 9 for connection to copper cable 10 or a different PHY 11 for connection to copper cable 12. Devices such as 7, 9 and 11 are typically constituted by a plug-in card or module.

Different PHYs or SERDES are employed for connection to different transmission media operating at different data rates. Figure 1 gives the example of a SERDES 7 which operates according to a TBI (10-bit interface) for connection to 'gigabit' Ethernet fibre optic cable, a PHY 9 which operates according to the IEEE GMII 10-bit protocol to connect to copper cable for operation at gigabit data rates and a PHY which operates according to the IEEE MII 5-bit protocol for connection to copper cable for 10/100 (megabits per second). Various other protocols for the media independent interface between the MAC and the intermediate physical layer device exist but the ones mentioned are the most common.

More recently, another implementation for a PHY has obtained acceptance. This interface is called RGMII (reduced gigabit media independent interface) and supports a reduced 5-bit media independent interface for PHYs that support data rates of 1000/100/10 megabits

per second for the transmission of Ethernet packets on copper cable. Furthermore, a 5-bit reduced SERDES interface has also obtained acceptance: it is termed RTBI (reduced 10-bit interface)

5 As previously noted, SERDES for fibre differ from PHYs used for copper cable in that all the ten input/output pins are data pins rather than a mixture of data pins and control pins as in a GMII interface for a PHY. The receive side of the MAC must synchronise to the 10 bits of data from the transmitter block of the SERDES by decoding the data which is encoded using an 8-bit/10-bit coding scheme in accordance with, for example, IEEE  
10 Standard 802.3. Likewise the switch's MAC transmit block must transmit 8-bit/10-bit encoded data to which the receive side of the SERDES must be synchronised. Synchronisation with the encoded or decoded 10-bit/8-bit data is achieved using specially coded characters or symbols. Examples of these are shown in Figure 2 which is a table of code group names, the respective octet value, the octet bits and those bits as represented by  
15 current running disparity value both negative and positive after 8-bit/10-bit coding. The designation of the octet bits (HGFEDCBA) and the running disparity bits (abcdeifgh) conform to IEEE Standard 802.3 Clause 36. The valid special code groups as shown in Figure 2 include a start of packet code group K27.7, an end of packet code group K29.7 and other code groups which may be used either alone or in combination with other valid  
20 data code groups.

Of relevance to the present invention is code group K28.5, which represents a comma symbol and is employed as the first code group of an idle (I2) symbol. It is followed in practice for this purpose by a valid code group known as D16.2, which has an octet value  
25 50, octet bits 010 10000 and running disparity (RD-) bits 011011 0101 (Table 36-1b in the aforementioned Standard). Several variants of the K symbol (K28.5) exist but the full set is decodable using the lower 7 bits. This means that it is sufficient to detect (0011111xxx) where x indicates 'don't care'.

30 As well as the newly defined RGMII and RTBI protocols, variants of SERDES protocols have been devised to support TBI and RTBI. In general the options include interfaces having a 10-bit code using a single clock or a 5-bit code using two clocks (so that the 10 bits of the K28.5 character are clocked in successive clock cycles).

The preferred embodiment of the present invention is specifically intended to detect automatically the interface protocol in use provided that it is either a 10-bit code or a 5-bit code and employs either one clock or two complementary clocks. In the 10-bit codes all ten bits of each group are available at the same time. In the 5-bit codes the ten bits are available in successive groups of 5 bits.

The idle and other symbols are encoded into the receive data streams to the MAC for all the device options, the actual coding being dependent on the number of clocks and the data bus width. A single receive clock scheme uses both the rising and falling edges of a single clock to latch in the 5 or 10 bits of data. The two clock schemes (one clock being inverted with respect to the other) employ two complementary clocks to clock in the data on their respective rising edges.

The different schemes are shown in Figures 3 to 6.

Figure 3 illustrates a 'DDR 5-bit - 1 clock' scheme which operates on receive data five bits wide. The first five bits (segment D0) are clocked in on the rising edge of the clock, denoted 'phyRxClk' whereas the next five bits are clocked in on the subsequent falling edge of the clock.

A 5-bit scheme employing two receive clocks, denoted 'phyRxClk' and 'phyNRxClk' is shown in Figure 4. Five bits of data are clocked in employing the rising edge of the phyRxClk clock and the subsequent five bits, segment D1, are clocked by the phyNRxClk clock.

Figure 5 illustrates a 10-bit scheme using a single receive clock. 10-bit wide data, of which the successive segments are shown as D0 and D1, are clocked using both the rising edge and falling edges of the receive clock.

Figure 6 illustrates a fourth scheme employing 10-bit wide data wherein successive segments of 10 bits are clocked using the rising edge of two complementary clocks 'phyRxClk' and 'phyNRxClk' respectively.

The present invention is a detector which distinguishes between different interface protocols by detecting the presence of the bits characteristic of the comma and following code group at times determined in accordance with the various protocols. In particular, internal clocks (both direct and inverse) are employed in conjunction with clocked delay elements (such as D-flip-flops), comparators (for detecting relevant bit matches) and coincidence detectors to detect the presence of the comma symbol in accordance with each of the protocols shown in Figures 3 to 6

Figure 7 illustrates schematically the disposition of the present invention in a known scheme such as Figure 1. Between the relevant connector 6 and MAC 2 is disposed a 'media detect' circuit 12 which will be described by way of example with reference to Figure 8. The purpose of the media detect 12 is only to determine which interface protocol is employed by the SERDES

Figure 8 illustrates in detail one embodiment of the invention. For the sake of simplicity it shows only one 'layer'. Some of Figure 8 is 10 bits deep whereas some is 5 bits deep but in each case only the gates for one bit are shown.

The detector is organised as a plurality of clocked detecting channels each of which is controlled by the respective clock system, including bit comparators (which may be common to more than one channel) in order to determine the presence of idle signals which conform to a respective interface protocol characterised by a particular clock scheme and code bit grouping (i.e. 10-bit or 5-bit)

The data input to the detector shown in Figure 8 are the 10-bit lines from the SERDES. This data input is denoted 'phyRxData[9:0]'

The clock inputs to the detector are a direct and inverse clock at the data transfer rate of the incoming data. These complementary clocks are denoted 'phyRClk\_int' and 'phyNRClk\_int' respectively. These clocks are internally generated and are presumed to correspond to the clocks which may be used by the SERDES

The detection of the 10-bit protocols is the simpler and is performed by the components shown in the lower part of Figure 8

Each of the ten data lines is connected to a respective set of three D-flip-flops 81, 82 and 83. Flip-flop 81 is clocked by the rising edge of 'phyNRClk\_int'. Flip-flops 82 and 83 are clocked by the direct and inverse versions of the clock 'phyRClk\_int'.

The (ten) flip-flops 81 are each coupled to a respective stage 84 of a bit for bit comparator for detecting the presence of the 10 bits D16.2 code (the second half of the I2 symbol). The flip-flops 82 are likewise coupled to respective stages 85 of a bit for bit comparator for detecting the 10 bits D16.2 code. The flip-flops 83 are connected to the stages of a bit for bit comparator 86 which detects the 10-bit K group (i.e. the first half of the I2 symbol). Each comparator provides an active output if all the respective input bits match the bits of respective predetermined code group. It would be possible to determine only the lower 7 bits of the K group.

The outputs of the comparators 84 and 86 are connected to inputs of a coincidence detector (represented by AND gate 87). The outputs of all three comparators 84, 85 and 86 are connected to inputs of coincidence detector (AND gate) 88. The input from comparator 84 is inverted (active low) so that coincidence detector requires TRUE outputs from comparators 85 and 86 and a FALSE output from comparator 84. If the SERDES employs the DDR 10-bit 1 clock protocol, all the relevant bits will be simultaneously clocked out of flip-flops 82 and 83 and coincidence detector 88 detects the simultaneous presence of the correct bits input to comparators 85 and 86. If the SERDES employs the DDR 10-bit 2 clock protocol (Figure 6), the relevant bits of the K symbol are clocked out of flip-flop 83 by the phyRClk\_int clock and the relevant bits of the D16.2 code are clocked out of the flip-flop 81 by the phyNRClk\_int clock. The existence of this protocol is detected by coincidence detector 87.

The upper part of Figure 8 shows the detection of the two 5-bit protocols in a manner similar to but more complex than the detection of the 10-bit protocols. The simultaneous presence of correct bits from the two code groups needs an additional stage of clocked delay.



The inputs to the upper part are the five lines [9] and [3 0] of the phyRxData lines. It is presumed that the 5-bit signals are carried on these selected lines. The five inputs are connected to a respective set of D-flip-flops 91, 92 and 93 of which flip-flops 92 and 93 are clocked by the direct and inverse forms of the 'positive' internal clock phyRClk\_int and flip-flop 91 is clocked by the 'negative' or complementary internal clock phyNRClk\_int. Flip-flop 92 and flip-flop 93 can provide alternative inputs to comparator 94 of which the output is coupled to an active high input of coincidence gate 95. Flip-flops 91 and 92 can provide alternative inputs to comparator 96 of which the output is connected to an active high input of coincidence gate 97. Flip-flop 91 has an output coupled to the D-input of D type flip-flop 98, clocked by the same clock, the output of flip-flop 98 being coupled to inputs of comparator 99 of which an output is coupled to an active high input of coincidence gate 97 and also to an active low input of coincidence gate 95. Flip-flop 92 has an output coupled to the D-input of a D-type flip-flop 100, clocked by the positive internal clock. The output of this flip-flop is coupled to the input of comparator 101. The latter detector is coupled to an active high input of coincidence detector 95.

Finally, D-type flip-flop 93 has an output coupled to the D-input of a D-type flip-flop 102, clocked by the inverse version of the 'positive' internal clock. The output of this flip-flop is coupled to the input of comparator 101.

In a manner analogous to that already described, where the outputs of comparators 94 and 101 are TRUE and the output of comparator 99 is FALSE, the protocol in use is the 5-bit-1 clock protocol as signalled by the output of coincidence detector 95. When the outputs of comparator 96 and comparator 99 are both true, the protocol in use is the 5-bit-2 clock protocol as signalled by the output of coincidence detector 97.